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REFLECTIONS ON GOVERNMENT SERVICE

II. Goal Setting and Feedback in Large Scale Endeavors

by

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Second of Three Lectures Presented in the
McKinsey Foundation Lecture Series

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II. Goal Setting and Feedback in Large Scale Endeavors

Throughout our history questions have been raised as to whether our American decision-by-vote process can stand up to the great tests required for survival and advance. Involved in these questions are tests as to our ability to effectively organize, administer, and reorganize as needed the large scale endeavors required for the demanding jobs that our pattern of development and circumstances thrust upon us as our nation goes forward. Some thoughtful observers have called our system "government by crisis." In the process of meeting many crises, our nation has made many advances. But the large scale effort approach cannot always be a response to a crisis. Its use in many cases must be more deliberate, more carefully planned, and more inter-related to a large number of other activities than crisis conditions will permit.

DeTocqueville focused on this area of doubt in a penetrating commentary a hundred and forty years ago. He did not doubt the resolve and the capability of Americans. He had no doubt that we would push on to the limits of this continent and build a civilization unparalleled in its wealth and material well-being. Nor did he seriously doubt our ability to take action to meet an external threat or a physical diaster. His doubts were more sophisticated, more fundamental. He could not assay what would happen when no crisis existed, and sovereigncitizens were called upon to vote on issues so complex and so far removed from their day-to-day needs and interests that they could hardly understand their nature or their implications.

Today modern technology is a ubiquitous and powerful force in all decision areas, individual and national. To predict the time, cost, and performance parameters of multi-billion-dollar projects requires an assessment of how well the effort can be organized and administered, as well as whether scientists and engineers will leave other things of high priority to join the effort. The limits to which engineers can use higher temperatures and higher pressures to achieve higher efficiencies is constantly changing. These kinds of considerations are difficult for the voter to understand and make judgments about.

Some governmental agencies have developed non-profit organizations and contractor-operated laboratories to help them make analyses; to develop information adequate for decisions; and to present the facts supporting those decisions in the forums that condition voter judgments. NASA has used a different method. We have worked hard to create in our specialized staff groups and in our laboratories the ability to arrive at judgments based on facts; an in-house technical and administrative competence that will enable us to reach correct judgments on the matters for which we have responsibility, no matter how complex. We thus are able to move these matters forward to the voter-judgment arena with confidence that they will stand up under scrutiny and debate.

Before and after the Civil War, during the period of near economic anarchy in the last decade of the nineteenth century, and the period of growing social consciousness in the early twentieth, de Tocqueville's question recurred again and again: Is our democratic system capable of handling the complex and difficult problems that our growth and progress generate with such force? This question became particularly pointed during the Great Depression of the 1930's. Faced with a catastrophe of unknown origins, almost imcomprehensible in its workings, and incapable of being met head on, as would have been a menacing foe or a natural disaster, our citizens became profoundly disturbed. As the historian Arnold Toynbee has pointed out, they "were seriously contemplating and frankly discussing the possibility that the western system of society might break down and cease to work."

As we face today a new series of tests at home and abroad, doubts again are heard. The overtones are perhaps even more somber than before. A general theme seems to be building up that we are over committed as a nation; that we have exceeded the limitations of our power; that we must either lower our goals and reduce the scale of our activities or risk the breakdown of our free system. Some question whether a government of divided powers such as ours can in any event meet some of our problems.

At the same time doubt is being voiced as to the buoyancy of the American people, as to their desire to continue pioneering on new frontiers, as to their willingness to carry on with great undertakings. Archibald MacLeish expressed the view in the Saturday Review of

October 7, 1967, that we no longer trust ourselves to carry on with the great goals that have long marked our society. He states a paradox in "the contradiction between the triumphs of human achievement on the one hand, and the profound uneasiness of humanity on the other . . . There is . . . a terror in the world . . . Under the hum of the miraculous machines and the ceaseless publications of the brilliant physicists a silence waits and listens and is heard. It is a silence of apprehension. We do not trust our time, . . . we do not trust ourselves."

David Brand, a British journalist writing in the Wall Street Journal of August 27, 1967, sees America as "boarding up, slat by slat its hopes, its trust, its technicolor illusions and even its sense of humor." He says: "The shadows are creeping in. And too many Americans are concluding that being American is not the best of all possible worlds."

Less than a month ago, Malcolm Johnson, Editor of the Tallahassee (Florida) Democrat, said much the same thing: "We have become a fearful people, we Americans--intimidated by the power, even the virtues, of our nation and its institutions. We seem to seek ways to emaciate our culture and our politics, dilute our faith, diminish our superiorities. . . . At home and abroad, we let humble motives run past humility to humiliation. Self-criticism has shattered self-confidence. Self-restraint is strangling self-reliance. We are like Curt Walters' old maid Aunt Sally--so afraid she'll do wrong, she can't do right."

For myself, I question the validity of these assumptions. Is our present situation really so bad? Is our spirit as a people so broken? Does this nation at the pinnacle of its power need to trim its sails and heave-to far short of the ends we have been seeking? Are we at a point where we must abandon our aspiration for a secure world community of free states, or our aim to use technology to bring to the service of ourselves and mankind the great continuum that begins with the ocean floor and extends through the air and on outward into the reaches of space? Can we do what is needed to save our cities?

Our resources today are at a level hardly dreamed of a few years ago; our gross national product is approaching the trillion dollar mark; our productivity in every field is reaching higher and higher peaks.

The knowledge we now command staggers the imagination. We have at our disposal large numbers of highly educated men and women; vast new technological resources; an almost miraculous capability to use existing technology to create new technology as needed. On an almost fixed time schedule, we are able to meet new needs or to effect desired improvements in our situation as a people and as a nation. And we have the ability, if we but use it, to organize ourselves, our knowledge, and our resources to accomplish almost any task or group of tasks we may set for ourselves.

As an illustration, what we have done in space may point the way. Some of it now seems commonplace. But let me recall how it was before. In 1958 we decided that we could not relinquish the control of space to another nation. We embarked on a program to seek pre-eminence as a space faring nation. As we proceeded toward this major goal we continually refined our projects and sub-goals. Within a ten-year period, we developed a capability to operate with both men and machines to perform in space scientific investigations of the earth, its environment, the moon, the sun, our neighboring planets, and the stars; to observe from space and to predict terrestrial weather phenomena; to use space machines to improve our ability to communicate on the earth; and to prepare for further exploration and application of this newly opened medium of space. We vastly expanded our knowledge of the air and how to use it as we learned to attain the high speeds necessary to overcome its limits and escape into the space beyond. We developed, refined, and added to the plans for attaining these goals. We began to work on many elements within these plans that would not become parts of an operational system within half a decade.

The development of the 36-story tall Saturn V with a thrust of seven and a half million pounds was begun in FY 1962 when the largest operational rocket we then knew how to build, the Atlas, could produce less than 400,000 pounds of thrust.

Here I might add a point that is little recognized. We conceived, developed, and will carry out this ten-year program in terms of a relatively small impact on our national resources. Total cost of the entire space program in this first ten years equals less than six percent of what we have spent on defense during the same period. The costs of space have amounted to one half of what we spent to develop an intercontinental missile capability. They accounted for less than three percent of the total of our federal expenditures during the period involved; they represented less than five one thousandths of our gross national product. Of the funds used, over 90% went to pay for work in the laboratories and factories of 20,000 prime and subcontractors and for research and training on the campuses of 200 universities. NASA provided the in-house base that enabled this large endeavor to develop its power. But the technology was developed, tested, and perfected in non-governmental units that were doing other work--serving other customers. The know-how spread out into large areas of industry. Efficiency was increased. Large parts of the public investment were recovered in taxes.

Is there any good reason why we cannot do in any number of other areas what we have done in space and without having to throw overboard other programs--at home and abroad--essential for our security, our progress, and our well-being as a nation?

My answer is that man's destiny is a product of his intellect. He appears to have no recourse if he is to progress but to engage by all means available in the endless search for new food for thought--new information which he digests to form new knowledge and on which he builds a better understanding of himself and his environment. This process is man's greatest continuing adventure. It is uniquely suited to constructively consuming all of his resources, mental and physical. But if knowledge and understanding are to be of maximum benefit to man, they must be put to work. Man has no way to do this on a broad scale except through organized society. Only as society sets demanding and imaginative goals and acts against those goals can the individuals who make it up realize upon and expand their overall capabilities.

Choosing goals in our society depends upon our desires as well as our capabilities. Most people of any society desire to survive; they desire physical well being for themselves and a chance for a fuller and richer life. But do they desire those things enough to temporarily burden themselves and even severely tax themselves in order to work over a longer period toward new levels of achievement--to enlarge knowledge and to apply it on a broad basis to the solution of long-standing problems? More particularly, will they choose this course when they cannot fully comprehend the nature and implications of all the issues involved?

Woodrow Wilson believed, as I mentioned last week, that the people of his day were determined to progress toward such goals.

He saw the nation as impatient for progress toward its promise and ready through new goals and new organized efforts to seize history by its forelock--to hasten the realization of its dreams.

In our early days, Washington, Hamilton, Jefferson, Franklin, and the others built upon a similar conviction. There was no assumption underlying their work more important than that individually free men would become collectively responsible men. They set a pattern of collective action and a governmental framework that has enabled a growing society to effectively exercise initiative in benefiting from new knowledge through use of new technology on a scale never before attained.

Why do we doubt our individual and collective ability today? Part of the answer may lie in the size and complexity of things. We have become a nation composed largely of specialists, a highly complex, interconnected, and interdependent system of people, groups, functions, and interests. This is in contradistinction to our early period when the westward advancing frontier provided opportunity and fluidity, and the pattern of settlement consisted of a relatively small number of loosely connected groups which could enjoy a quasi-independent existence.

Our ways of thinking and acting go back to those days. We have a concern over "bigness," whether in the form of big business, big government, big science, or whatever. We have helped make things grow bigger throughout our history, but we still tend to fear bigness itself. This represents perhaps a sound instinct. Large aggregations of power can be dangerous to free men and free institutions. They need not be but many are.

Thoughtful scholars today are challenging Lord Acton's thesis that all power corrupts. Lord Radcliffe developed in his Reith lectures the theme that, "power is good or evil according to the vision that it serves." My experience has been that most men responsible for organizing large scale efforts and, therefore, large concentrations of power seek to achieve their ends within the existing system, or desirable modifications of the existing system. My own view is that goals, projects, and systems must, in the last analysis, be viewed as interdependent elements; and goals that depend on undesirable systems are undesirable goals. Cooperation is desirable; loss of independence or individuality is not. The classic and continuing goal of our society is to preserve those basic freedoms and rights that have been won for responsible individuals, and the essential bases for cooperation between responsible groups within the framework of representative government.

Some who discuss the difficult problems we face today contend that to meet our goals we need to eliminate some of the restraints of our democracy and of our federal system. Some feel that history does not show a basic and unbridgeable difference between the <u>essentials</u> of our system and a collectivist system.

Their view is that those who adhere to collectivist principles, as in the USSR, are moving steadily toward our practices. They feel we have little choice in our turn but to move toward certain of theirs. Others suggest that we can always count on the "crisis" pressures to enable us to superimpose on our system a special or crash program with overriding powers when it is clearly necessary.

My own belief is that in the long run, perhaps even in the short run, both of these approaches leave much to be desired. Neither is really necessary. I believe we can use our growing experience with large scale endeavors to learn more about the art of government; of how to combine skillful organizing and good management in advance of a crisis need. I believe we can set-up to do the complex jobs we have to do without damage to our democratic principles or representative system, and that we can do this with benefit and not harm to the fundamentals of our society. But we do need a large increase in the research effort from which we can learn how large endeavors can so operate as to bring to the fore, for citizens to evaluate, the essential ingredients of complex matters. This evaluation must meet the critical tests of acceptance by our elected representatives after full debate. There is no basic reason why a large scale effort cannot set up to provide the kind of information and facts that can become a trusted source of information for citizens and a basis for judgments. I believe these endeavors can learn how to report in understandable form whether or not the things the endeavor was set up to do are, in fact, being accomplished. In many areas of such endeavors we need not despair that we can learn to do both work and the reporting with the television cameras on us--when thoughtful citizens want them there, not just when we are ready to report or when a reporter seeks a sensational setting. In other words, I believe we can so conceptionalize the large scale endeavors we need to do our work and so conduct them as to lead to acceptance of this way of working as proper and safe.

This is not an easy undertaking. As I tried to make clear in my first lecture, to meet the complex requirements of this age neither the existing doctrines and practices of management nor the present art of public administration alone or in simple combination is sufficient. We need something more and I believe much of this can result from an active support of research in the critical areas. Research is much needed to give us a systematized way to do things that both furthers and integrates into a new whole the science of good management and the art of good public administration as they apply to large scale endeavors. Successful large scale endeavors have repeatedly shown what can be done. We know less about how it was done. The purpose of these reflections from my own experience is to try to show promising paths of exploration and study.

I would single out as one of the most important, and I believe the most neglected, aspects of most large scale endeavors the relationships between the primary goals and the accompanying sub-goals. The second- and third-order effects must be better evaluated in predicting its total effect on our society. Lack of a trusted way to demonstrate that we can keep under control second- and third-order, as well as primary, effects of an endeavor carries concern and fear. If, therefore, we are to systematize the use of the large scale approach and to secure its availability as an accepted way for a free society to operate, we need to develop more reliable ways to predict and manage the totality of its consequences. In many ways, we need the same kind of innovation which enabled the Wright brothers to succeed where others had failed--a system of coordinated controls that will provide a way for the central groups of administrators in a large scale endeavor to use natural reactions based on understood experience to guide what is in many ways a conglomerate that has a built-in instability and thus maneuverability.

The large scale endeavor by its very nature--that is, because of its sheer size, its complexity, the investment it requires, the aggregation of power vested in it, and the diverse and highly skilled human resources it must command--necessarily impacts large segments of society with great force. This is true whether the endeavor is private or public; whether it aims at a military or civilian end, or a combination of the two; or whether it is directed toward solution of a social problem or development of a new national capability.

Most large scale endeavors employ--as well as develop--new scientific knowledge and new technology. The essential product of this process is change--that is, change in the attitudes, the interests and the concepts of reality of large numbers of people. This comes through the acquisition of new knowledge and in the changed methods of action and interaction of people as this knowledge is put to use. It follows that the larger the effort in science and technology, the larger those changes will be and the more rapidly they will occur. The effect is to upset the dynamic balance, or equilibrium of society. The bigger the effort in science and technology, the less can large numbers of people count on previous bench marks, or points of reference, or guides to action.

The hard fact of life for organized society and its leaders today is that if dynamic equilibrium is achieved at any one time it becomes increasingly difficult to maintain. This is especially true when it is upset by a number of large innovations not introduced with the most careful consideration of their second- and third-order effects. This suggests that new and improved methods must be brought into play to analyze and prepare for the introduction of major innovations. These methods must include not only consideration of the material results which the innovations are primarily intended to provide, but also the intellectual response time of humans, the inertia of human systems, and the interaction of human endeavors with their supporting physical and social environment.

Professor Elting E. Mor~~r~~ison did an intriguing study of the stubborn resistance of the American naval establishment at the turn of the century to an important innovation in gunnery, one that would improve firing accuracy by some 3,000 percent. In trying to explain this resistance, Professor Mor~~r~~ison concluded that by far the most important factor was that the Navy is a society and that as a society it felt itself endangered by such a sweeping change. Professor Mor~~r~~ison went on to consider the implication for our society as a whole. "We are," he said, "a society based on technology in a time of prodigious technological advance and a civilization committed irrevocably to the theory of evolution. These things mean that we believe in change; they suggest that if we are to survive in good health we must become an 'adaptive society'. By the word 'adaptive,'" Professor Mor~~r~~ison explained, "is meant the ability to extract the fullest possible returns from the ideas and materials presented both by the past and present and to throw them into new combinations." But, Mor~~r~~ison adds: "We are not yet emotionally an adaptive society, though we try systematically to develop forces that tend to make us one. We encourage the search for new inventions; we keep the mind stimulated, bright, and free to seek out fresh means of transport, communication, and energy; yet we remain, in part, appalled by the consequences of our ingenuity and too frequently, try to find security through the shoring up of ancient and irrelevant conventions, the extension of purely physical safeguards, or the delivery of decisions we ourselves should make into the keeping of superior authority."

In NASA we have learned that for success in our work we must make the most careful analysis of all factors at the start of a project and still be prepared to adjust when actual conditions turn out to be different from those foreseen. We strive toward this goal just as we do to understand the relationships between the earth and the sun. Our "integrated systems" approach has proved vastly more effective than the "independent components" approach of the past for the solution of problems in dynamic situations such as are encountered in space and in weapons development. We believe the integrated approach should not be limited, as much present day thinking suggests, to "hardware" problems. It should extend to the total of the medium in which a job is being done and should encompass the full range of ramifications and implications.

The National Academy of Arts and Sciences is conducting on behalf of NASA a comprehensive study of the whole area of the relationship between large, complex endeavors and society. I mentioned one of the volumes resulting from this study last week, that on the railroads. Another entitled Social Indicators, edited by Raymond Bauer, appeared recently. This volume is deeply thoughtprovoking and deserves a close reading by anyone concerned with the great matters thatnow face us and will face us in the future. Dr. Bauer's premise is that: "In the conduct of human affairs, our actions inevitably have second-order consequences. These consequences are, in many instances, more important than our original action . . . technical changes have proved to be particularly explosive sources of second-order social, economic, and political changes that were never envisioned. This arises largely because at the beginning technical developments tended to be viewed in a rather restricted context. They are seen as an answer to an agreed problem and tend to be judged in terms of their adequacy in solving the problem."

The point of emphasis in this statement is that Professor Bauer sees second-order changes (or effects) as "never envisioned." This raises a fundamental question about large scale endeavors: whether it is necessary to proceed in the blind, as it were, with regard to their possible second- and third-order effects.

In the case of some endeavors we have indeed proceeded in this manner. The Manhattan District object was to get one job done, as it was with Polaris, and the development of an ICBM missile capability. Consequences beyond or outside the prime object were in these cases given little consideration. But certainly in the future we do not have to take such a narrow approach. We know enough today to set our goals to encompass at least some of the secondary and tertiary as well as prime effects and benefits.

We in NASA have had such considerations very much in mind as we have developed the goals and projects of the national space program over the past ten years. We have sought, on the one hand, to minimize the disruptive effects of what has necessarily been a vast undertaking and, on the other hand, to so conduct our operations as to strengthen in every way feasible the positive values of our society and its institutions. We rejected a proposal by one large industrial firm to do the entire lunar landing job single handed, as well as a similar proposal by a leading university to operate a laboratory that could do all the scientific research.

We decided as a matter of deliberate policy to place principal reliance on the American industrial establishment and the American university system as a whole. We decided to focus our governmental efforts principally on developing the needed in-house competence to make responsible decisions and on <u>organizing</u> and <u>managing</u>. A measure of what we had in mind is the fact that ninety percent of every dollar that has come to NASA has moved outside the Agency. Our purpose was to spread the difficult problems over the largest number of able minds in the belief that this would produce the best answers. We recognized that to be effective in this approach NASA had to have very strong scientific and technical in-house capabilities. We had to be able to spell out general requirements for industry and weigh the specific proposals they submitted. We had to both encourage research and evaluate projects proposed by universities. We had to evaluate contract and grant proposals; to judge the performance of our non-governmental partners; and often to help them work around the broad problems in all areas which required the development and application of new technology, new production techniques, new tests, and new laboratory experiments.

In our relations with industry we sought to use the profit motive with full effect, even though we had to get research and development done where there would be little or no follow-on production. We viewed the operations of the market place as forces which were well understood and better for our purposes than new and untried ideas. In the beginning we used competitive proposals and the cost-plus-fixed-fee types of contract. But as NASA-industry relations matured, we worked together to make improvements. In major developmental activities the fixed price contract was of little value because there were too many uncertainties. In many projects requiring quick reaction changes based on test results, we developed and applied the "award fee" approach wherein an appraisal by the government of the contractor's efficiency and performance determined the fee to be received. Extensive use of incentive contracting also came into play.

These were the kinds of sub-goals that made our prime goals realizable. One excellent example of a well established set of incentives that contributed greatly to both our primary and sub-goals can be cited here--namely the contract with the Boeing Company to produce five spacecraft to photograph the moon from lunar orbit. The contract had incentives on cost and delivery schedules. Further, there was an award for spacecraft performance in orbit about the moon. The fees were substantial enough to provide real incentives. The results achieved: five successes out of five missions on schedule, a substantial fee reward for Boeing management, and substantial savings for the government.

Our programs for work with scholars and universities have been as carefully worked out as those with industry. We have needed a very high level of scientific thought, experiments that would relay accurate scientific measurements from positions millions of miles away, and excellence in overall support of our missions. At the same time we worked to provide new means through which university resources useful for university purposes could be strengthened.

One effect of our programs was, as Dr. Sam Silver of the University of California has expressed it, to "tantalize the curiosity and stimulate participation by providing the opportunity to be creative."

The development of NASA's goals in science and programs for working with universities involved a selection from among several alternatives. One approach would have been to state the projects in the form of immediate objectives and then request proposals from the academic community. This would have generated response, but could have had two disfunctional effects. Firstly, the academic community is strongly opposed to the appearance of a "market place" approach. Proposals might not have come from the best scholars. Secondly, and perhaps more likely, most of the research support would have ended up with those institutions which had already achieved the highest scientific reputations. Not only would this prevent the further development of a broad cross section of universities, but "name schools" would become overloaded. In this case NASA broke with tradition and supported research not <u>only</u> on the basis of demonstrated scientific excellence, but <u>also</u> in a pattern to build up the capabilities of institutions with a growth potential and a promise of using added resources to attain excellence.

It was clear in 1961 that NASA was required not only to replenish the national pool of highly trained scientists and engineers from which it was drawing, but to increase it. Therefore, not content with the added stimulation of pre-doctoral work provided by the increased amount of NASA's basic research performed by scholars in the universities, we initiated a pre-doctoral training program aimed at producing 1,000 doctorates annually.

The way this was done again broke with tradition, but was more effective in supporting both primary and sub-goals. The policy previously followed by federal agencies had been to allocate funds to individuals chosen through nation-wide competition. Once the individual was chosen he or she would have freedom of choice as to which institution to attend. This had the effect of overloading "name universities," a failure to build up added competence in a large number of institutions, and leaving in the mind of the graduate student attending an institution of his "second" or "third" choice an impression not good for him or the school he was attending. In contrast, NASA followed the policy of providing its pre-doctoral training grants to the universities, allowing them to choose the graduate students and thus commit their brains and resources to their own selectees. This policy strongly supported the objective of institutional development as well as accelerating the addition of new Ph.D.'s to the national pool.

Through special features of NASA's Sustaining University Program, the objective of fostering inter-disciplinary approaches to research and problem solving was emphasized. Universities were encouraged to adopt multi-disciplinary approaches to all appropriate research projects. The purpose or sub-goal was that if an economist or sociologist could contribute to a physical science-oriented research project, his involvement should be encouraged and both the fields of social science and physical science would gain.

This goal of encouraging the build-up of inter-disciplinary capabilities is, I think, one of great importance for the future. Today may be the age of the specialist; and in so far as this description denotes intense application of talent to a given area, this is true; but the time has long since arrived when the complexity of the environment also demands a fusion of the various disciplines. The engineer cannot discharge his responsibilities without the counsel of the scientist; the industrialist cannot succeed without the economist. If this inter-disciplinary approach could be expanded by the universities, and a broader base of wisdom and understanding on today's opportunities and problems created, industry and government could realize great value from working through the university with all the disciplines need for what is called today "a sophisticated understanding of the atomic and life processes." In our society, the university alone generally includes all the disciplines needed for this understanding--and leaders in every field need to know what all the disciplines can tell them. The university needs to recognize that it could become much more of a "trusted source of knowledge" in our society.

To go further with this approach is a needed national goal. NASA has only scratched the surface enough to show there is a "gold mine" in this region. Some way to explore and develop means whereby broadly based multi-disciplined teams can carry on as a continuing matter, research and research related studies needed by cities, state governments, federal agencies, industry, and other segments of the nation's life and can feed the results on a regularized basis into the appropriate "point of main impact," is much needed. I have long felt that one of the greatest forces we could bring to bear on the problems of our cities would be the development of great urban universities capable of purposefully and systematically generating within the urban environment itself the knowledge, as well as providing training for highly skilled and creative people, needed to work successfully with those problems. I know of no single American city that has an adequate research effort or an adequate laboratory of the type truly great urban universities could provide. To do this, even in the turbulence of today, is not an impossible goal.

The American university represents one of our greatest national resources. No other nation in the world possesses its parallel. James Brian Quinn said in the Harvard Business Review of August 1966 that, "Perhaps the greatest--and least recognized--asset the United States has in international technological competition is its educational system. To fully develop its industrial science and technology, a country's educational structure must provide a full range of needed skills--scientific, engineering, manufacturing, management, technical, and even clerical--and constant opportunities for the upgrading and modification of these skills to meet new demands. In the Western World," Quinn concluded, "the U.S. educational system has adapted to the requirements of advanced technological culture with far greater efficacy than any other system."

We have sought in NASA, and I feel with good success, a working partnership between the universities, industry, and government. We have done this while each of the three has remained in its traditional place and has operated in traditional ways. I believe each of the three has become stronger because of the partnership. I believe also that the partnership has yielded a product in terms of useable resources greater than the sum of its parts. This is something I would think of great importance for large scale endeavors of the future. We need not only to continue with this partnership; our goal should be to refine and further develop it.

Many large scale endeavors--I would in fact say most--generate new knowledge and new technology. These can be of enormous benefit to our economy, to our society. They can enable us to advance on a broader front and at a more rapid pace than otherwise would be possible. Normally these added benefits of a large undertaking are expected simply to "spin-off" into the main stream of our society, and to a certain extent they do, as witness the benefits for industry of military research in World War II. But can we afford to wait for or to rely solely upon the workings of such a slow process? The enormous expenditures for scientific research and development in large scale endeavors have the potential to contribute more to economic growth in the next decade than any other single factor. NASA has recognized this and with it that the maximum transfer of technology to non-space use should be purposefully and systematically sought.

We early introduced as a basic element in our operations a Technology Utilization Program. In this program intensive efforts have been and are being made to identify new products, new processes, new scientific and technological knowledge, and all useful innovations. Some appear in our research centers, some in our contractors' plants, and some in university laboratories. We endeavor to make these products known and available for as wide use as possible. The extent to which useful "transfers" of space technology to the civilian economy take place will always depend in large measure on the initiative shown by people in industry, but NASA has established specific programs with private research organizations and universities to help spur and facilitate this initiative. Illustrative of our success is that in 1967, 4,600 items of new technology were reported and evaluated to determine the significance for those outside the aerospace industry. Items with potential were brought to the attention of industry, education, and the professions in a variety of ways. In 1967 alone, six hundred and seventy-eight different NASA "Tech Briefs," which are publicly sold through the Clearinghouse for Federal Scientific and Technical Information, have been issued, and the Clearinghouse sold some 270,000 copies of these; they are among the "best sellers" of all government publications.

A novel element in our transfer process is the experimental or "pilot model" Regional Dissemination Center. There are six such centers at universities in different parts of the country in different stages of development. These centers are established as pilot models and are expected to become self-supporting within five years. The Indiana University Aerospace Research Applications Center, for example, is now entering this non-subsidy stage. At these centers, NASA information on new technology is stored and retrieved by computer methods. Flash reports followed by Tech Briefs are then distributed to commercial and other clientele whose "profiles of interest," also computerized, show a need. These pay the center a fee for the service. The centers also act as a repository for detailed information which can be called for by the clientele.

NASA is also experimenting with specialized centers, such as the one at the University of Georgia which disseminates NASA computer software to industry, universities, and others. This represents considerable saving for the recipient who pays only a modest fee for a program which may not give him 100 percent of what he needs, but which cuts his costs substantially. In 1967 over 1,000 such computer programs were sold by this center as well as 8,600 sets of program documentations.

Other "transfer" means being used by NASA are: conferences co-sponsored by NASA and the Small Business Administration; exchanges through other government agencies, such as the Atomic Energy Commission, HEW and the Commerce Department; and business and technical publications--where approximately 1,200 articles in 300 magazines appeared in 1967.

It would, of course, be impossible to enumerate all of the examples of technology transfer; but a few are worth mentioning. NASA-generated technology has contributed ultra-reliable devices for use in articicial heart technology. Through the use of satellite communications two-way medical consultations are possible between continents. Televised explanations and demonstrations of new and radical medical procedures and surgery can be shown to medical students as they take place thousands of miles away. NASA developed means for efficiently soldering high-tensile metals, of the kind that would operate in space, are finding application in the oil industry for their down-hole equipment. NASA research regarding the role of the remarkable building blocks called nucleic acid that form the base of all living things may aid in understanding how life evolves and may also give new insight into diseases of the aging. In searching for a safe method of softening the impact of lunar landings, NASA specialists developed an especially efficient shock absorber, an aluminum tube that controllably collapses on impact, taking the brunt of the shock. Satellite pictures are now used to study changes in the ice fields in the north. They can help forecast the break up and therefore permit the more efficient use of ice-breakers and reconnaissance aircraft.

NASA has similarly sought to strengthen the economy of the nation through its policy with regard to patents. The National Aeronautics and Space Act and NASA contracts stipulate that any invention made in the performance of the contract becomes the exclusive property of the government. In order to facilitate the introduction of items with economic value into the stream of commerce, NASA encourages the non-exclusive licensing of NASA patents. Exclusive licenses are also granted when an extra incentive is required to get the needed developmental research done. In all cases, however, production of the product must follow or licensing is granted to others.

NASA's concern that our large-scale space endeavor brings new and added strength to our society at the same time that it progresses toward its primary goal of an adequate space capability represents, I believe, a desirable prototype for other large scale endeavors which we will certainly undertake in coming years. Unless such endeavors are conceived in terms of multi-purpose goals that add to the all-around development of our society, they can only lead to the distortion of our system or drown it.

But our concern about the effects of large scale endeavors should not stop with impacts of the type I have just discussed. We need to go on and explore the larger consequences that any great endeavor is likely to produce on our basic values and our fundamental relationships with each other. We need to develop means of forecasting these and of obtaining a feedback of information that will show what is actually happening as an endeavor proceeds along its course. This can serve to raise alarm signals if effects are not those desired.

As Dr. Bauer said about the space program in Social Indicators, such impacts can be very far reaching: "They may include changes in man's conception of himself and of God; almost incredible consequences of vastly expanded communications via satellite communications systems; improved short- and long-range weather forecasting; . . . contact with beings higher, lower, or sideways from us, or, if there is no contact, speculation over the possibility of contact; . . . competition with the Russians, cooperation with the Russians, or some combination of the two; . . . changes in attitudes toward education and toward stupidity;

revolutions in medicine via new knowledge, via telemetry, new substances, and use of computers for diagnostic purposes; revolutions in data processing and retrieval . . ."

These are the sort of consequences we must ponder as we undertake new endeavors. These are the sort of things that should enter into our calculations and plans and operational procedures as much as costs and measurable benefits. We need for each new large-scale endeavor, as Dr. Bauer further said, "to establish a system of feedback for detecting and taking into account the full range of its actions and for guiding its future actions."

In the meantime, we have another solemn obligation to our society. We must so develop and manage large scale endeavors as to avoid violence to our system of government. One aspect of this problem is to limit "bigness" to the extent we possibly can.

When a major new undertaking is decided upon, the first thought is usually to create an entirely new and all encompassing organization to take care of all its facets. But can the nation afford a continuing proliferation and build up of public organizations? What is the alternative and will it work? Let me again take the experience of NASA as a case in point. When NASA was put on a large scale basis, it was clear that the easiest course from the managerial standpoint may well have been to take the new organization route. NASA's decision, however, was to rely principally on existing organizations. This decision naturally raised many serious and difficult administrative problems.

The requirement was to synthesize a number of enterprises that were widely scattered geographically and quite different in purpose and operational methods and procedures. We had to develop a truly integrated and smoothly functioning operation on the basis of these several disparate enterprises. The process was necessarily slow. But we gained many advantages from the approach, including a quicker build-up of effective momentum than would have otherwise been possible. And from the national standpoint we minimized the strain on resources and the disruptive impact of a new and complex undertaking.

Most important of all, perhaps, is that we have carried on the endeavor in careful recognition of the necessary participation of our legislative leaders. This requirement is one most likely to gall anyone who is concerned with simply "getting a job done." For certainly our representative system with its numerous checks and balances and its other obstacles to "business-like efficiency" poses numerous problems and difficulties for a large scale endeavor. Yet, if we do not consciously work to strengthen the very basis on which our society rests, what value can any great particular accomplishment or accomplishments really have? There is much to learn in this all important area from our past experiences.

In our pluralistic society any major undertaking requires for success a working consensus among diverse individuals, groups, and interests. A decision to do a large, complex job cannot be simply reached "at the top" and then carried through. Only through an intricate process can a major undertaking be gotten underway, and only through an intricate process can it be kept going. The basic decisions that initiate and set the pattern for a large scale endeavor are made by votes--within the Administration, of members of Congress, and the Citizens who elect them. Votes determine whether the endeavor is to be started. Votes determine whether it is to continue, and at what level, at what tempo, and for what changing or developing purposes. The voting process is an integral part within the operation itself. It constitutes an essential element in the system by means of which the endeavor is carried forward, just as the atmosphere on which an aircraft depends for support and movement constitutes an essential element in its operational system.

The area of main impact of votes within a large scale endeavor is that of goal setting and performance against goals, and the key is willingness to vote necessary support. Support is voted not in terms of organizational needs, as is usually the case with a routine type operation, but is in terms of the goal to be served and its assumed need, and the work being done to achieve the goal.

The process of decision-making by counting votes might seem a simple straightforward matter. In practice it is complex and difficult. For the endeavor to begin, the basic goal must have general, or at least majority support; so must follow-on subsidiary or implementing goals and activities. Performance must give acceptable evidence that goals are being adhered to and a satisfactory rate of progress maintained. Unfortunately, the large complex endeavor does not lend itself to the same sort of accounting in this regard as routine endeavors. You often cannot point to a series of accomplishments that can be measured in dollar-cents or other mechanistic terms. In detailing progress under a Marshall Plan what value do you attach to the reversal of the tide that seemed likely to produce a communist victory in the Italian elections of 1948? For a Point Four Program, what worth do you assign to the fact that during a given fiscal year not one of the newly indepedent states of the world adopted the Soviet system and joined the communist camp? How do you measure the checking of soil erosion in a Tennessee Valley or the virtual disappearance of pellagra?

For a technologically oriented endeavor like the space program, there are certain concrete things that can be pointed to each year; for example, in 1967, we successfully flew 20 out of 22 missions including small reentry tests, an orbiting biological laboratory, three operational weather satellites, six automated lunar missions, a probe to the planet Venus, and the first all-up Saturn V test flight; or in 1968 that we completed the automated phase of lunar exploration, man-rated the Apollo Lunar Module and are preparing for the first manned Apollo flight in earth orbit in the redesigned Command Module. But a vast number of things cannot be put in concrete terms. What of the knowledge we have gained as to what happens to the human being under varying conditions of stress? We are finding out more and more about almost every conceivable use of energy; about the nature of materials; we have learned how to use simulation on a scale and over a range of activities never dreamed of before; we are carrying out studies regarding extra-terrestrial life that seem likely to explain at long last the mystery of the origins of life on this planet.

How do you measure these accomplishments? Or on another side, how are we to weigh the performance that enabled us to deflate the skillfully employed bluster of Khrushchev over Soviet space superiority?

A vote in support of goals is not a one shot, over and done with affair. Votes must be counted again and again, almost continuously in fact. Moreover, the criteria by which goals and performance against goals are judged are highly variable, in more or less constant flux in fact. A single failure in the conduct of operations can bring a clamor for change in direction. An internal conflict; claims and charges of a disgruntled individual or group from within the operation; an action of a powerful interest group; a miscue in the information-media field; any one of these or other untoward circumstances can lead to the same results.

A partial success for the endeavor, one that "takes the heat off," so to speak, may also significantly affect voter attitude. Meanwhile, basic standards being applied to the endeavor and its goals and performance may be altered by events and developments in outside fields of activities, as for example, a prolonged foreign affairs crisis; a change in the general economic situation; loss of a powerful congressional leader; a domestic crisis or disaster; a struggle for control over a labor union; a shift in the political balance; the build up of pressures for some other large, complex and costly undertakings; and on and on.

Then there is the most fundamental thing of all: The public mood--the basic attitude of the people toward the goals being sought through the endeavor and the resulting effects. To gain and sustain popular support of a large and costly endeavor is an extremely delicate and complicated business, and particularly since only in the rarest of instances can direct personal benefit result. Moreover, as endeavors become more and more complex, a greater and greater degree of confidence and trust is required of people to vote and keep voting their support.

In practical terms, what does getting the votes required for both continuing policy support and continuing resources support of a large, complex endeavor involve? Can the executive in charge simply point to his "mandate" to do a good job and demand that he be given what he needs to carry on with it to completion? The executive who stands too firm in this posture is almost certain to fail, and the job with him. The sophisticated might say that the executive who makes adjustments is little better off, since he becomes a bargainer likely to compromise away the essence of the endeavor. But while this may be true, it should not be true. An executive can practice the art of the possible, or the best possible. When he has to adjust to a change in the environment in which he is operating, he must seek to limit his adjustment to the highest common denominator in the changed environment and refuse to accept the lowest. Whether he succeeds in this is the test of the successful manager of a large scale endeavor, a test of his ability to follow sound practice even though he has to depart from established doctrine.

An important example will illustrate the point: When the Marshall Plan was launched, the leadership of the Republican Congress insisted on a Republican administrator for the recovery program. The object was to establish congressional (i.e. Republican) control over the entire endeavor. President Truman, as President, could not permit the loss of control over a matter so central to the nation's foreign policy. Yet, he had to have Republican support or accept failure of the endeavor. The solution was a series of intricate moves and arrangements whereby Republican Paul Hoffman was named head of the Marshall program but the money and the power were channeled through the President, thus insuring that this important endeavor would be responsive to its true head, the President and executive branch of the government.

What I am saying is what I emphasized so strongly last week. The environment is a part of the large scale endeavor. Where the routine endeavor is influenced by its environment and acts upon its environment, the environment is integral with a large scale endeavor. Basic goals are a product of the environment. Basic goals, subordinate goals, and operating goals must be constantly adjusted to take care of changes and turbulence in the environment. Feedback of information, of signals of all sorts, from the environment must be constant, sure, and on a real-time basis. The course of a large,complex endeavor cannot be set and corrected by "flying by the seat of your pants." It not only must have an effective feedback system, it also must be internally so designed as to be able to make corrections in course and adjustments in performance as work progresses.

The voting process is basically an expression of will. It represents a decision favorable or unfavorable to some line of action. It determines at any given time what we as a nation are willing to do and what we are not willing to do. It is a dynamic proving ground for our national goals--all of our national goals, great and small.

It has been rightly said that the paramount goal of the American people was set long ago in the Declaration of Independence and that it is "to guard the rights of the individual, to ensure his development, and to enlarge his opportunity." But this goal, universal as has been its acceptance among us, has been a living vital force in our society only to the extent that we have voted over time for particular steps and particular measures to fulfill its vision. Our forefathers set the goal, but we of successive generations have had and continue to have the responsibility for giving it meaning in our time.

The President's Commission on National Goals, which in 1960 so simply and yet so eloquently pinpointed this most basic of our national goals, saw us as still being tested by the mighty vision it represented. "Our enduring aim," the Commission's Report stated, "is to build a nation and to help build a world in which every human being shall be free to develop his capabilities to the fullest. We must rededicate ourselves to this principle and thereby strengthen its appeal to a world in political, social, economic, and technological revolution. In the 1960's every American is summoned to extraordinary personal responsibility, sustained effort, and sacrifice."

We no longer have the great advancing western frontier from the mastery of which we drew such massive strength and vitality. But we do have a far vaster frontier on which we can draw in the future: the frontier of new knowledge. If we are to fulfill our destined role in a world in revolution, it is essential that we constantly find better ways to spread our most difficult problems over the largest possible number of able minds, and to generate the kind of creative thought processes and experimental procedures and systems that have enabled us to make such striking progress in particular areas such as space.

What we are doing in space and what we must do to perform other of the trying and demanding tasks that lie ahead is to bring into being new capabilities. Down through the course of history, the mastery of a new environment, of a major technology, or of the combination of the two as we now see in space, has had profound effects on the future of nations; on their relative strength and security; on the relations with one another; on their internal economic, social and political affairs; and on the concepts of reality held by their prople. From the elements of each such new situation which history records have followed many of the greatest strides of nations and of man.

I believe that our accomplishments in space and in other of our large endeavors have laid a foundation on which we can usher in a new era of advances. I believe this primarily because among those accomplishments has been a fundamental improvement in man's ability to do research and to use knowledge. These include the new ways in which large-scale organized efforts are managed; the encouragement of multi-disciplinary effort not only among the scientific disciplines, but involving engineering and the social sciences; the new techniques and tools for the conduct of research, and the manner in which these are applied to the solution of age-old scientific, social, and technical problems.

These and similar accomplishments fortify, I believe, the faith voiced by the President's Commission on National Goals in 1960: "To preserve and enlarge our own liberties, to meet a deadly menace, and to extend the area of freedom throughout the world; these are high and difficult goals. Yet our past performance justifies confidence that they can be achieved. . ."

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